commercial sector. Group III nitrides and the various substrates that support it, such as SiC and sapphire (and the list is growing) are the darlings of the LED and laser diode worlds as they produce the necessary blue to round out the primary colors in the spectrum. (See "Optoelectronic Update" in CSID, and in next TFR issue for more details). This huge commercial marketplace for outdoor displays, traffic and auto lights, and eventually white lights and increased capacity CD-ROMs helps further the development of WBG semiconductors in general, thus helping fuel the development of WBG materials and devices for HTE applications.

However, all the developers worldwide share the same fundamental material and device problems that must be overcome if yields are to reach acceptable levels. Applications for the WBG semiconductors in high temperature applications is still in the future, for the cold hard facts in the high temperature game are the same as they were for GaAs as it struggled for niches silicon couldn't fill. If you can do your design with silicon, you'd be crazy not to. But just imagine what you could do with SiC ICs when they become available, affordable, and reliable...off high volume fab lines?

SILICON CARBIDE's TOUGH STUFF!

SiC has various attributes that sets it apart from the field. First and foremost, it has a decent supply of commercial wafers already moving through the initial marketplace, by more than one supplier. More importantly, those wafers are made from usable single crystal material–a basic requirement for commercial success. Although the starting material has not yet lived up to its potential, and is still pricy, the positive technical attributes of those wafers makes SiC desirable for HTE applications. As Chris Harris of the SiC Group at Industriellt MikroelektronikCentrum AB (IMC in Kista, Sweden) so eloquently puts it, "above all, it is the physical properties of SiC that ring to its merit and excite even the dullest to its potential."

WBG semiconductors are inherently less sensitive to increased temperatures. "The thermal conductivity exceeds even that of copper; any heat produced by a device is therefore quickly dissipated. The inertness of SiC to chemical reaction implies that devices have the potential to operate even in the most caustic of environments. It is extremely hard," IMC's Chris Harris goes on to explain. "Of importance to our nuclear and space age is the fact that SiC is extremely radiation hard and can be used close to reactors or for space electronic hardware. Less transparent are the properties of particular importance to the device design engineer, high electric field strength and high saturation drift velocity." Those inherent qualities mean that devices can be made smaller and more efficient. "SiC is a material with which it is possible to stretch the limits of conventional technology to its extremes," he explains. Those are precisely the attributes that major customers, such as engine manufacturers in automotive and mil/aero sector are looking for. An excellent source for details of SiC makeup and polytypes are available on IMC's website: < http://www.imc.kth.se/kraft/whysic.htm >

WHERE IS THE MARKET HEADED?

As reported last issue in my report from the HiTEC meeting in Albuquerque, AEA Technology of Oxfordshire and Magus Research of London, presented preliminary findings from the first market study of its kind for HTE. The researchers estimate that the actual market for HTE in 1994 is estimated to have reached a definitive level of $140.1 million, and forecast the HTE sector to grow, in US terms, to $1.3 billion by 2005. According to AEA and Magus, well logging equipment, aerospace, and automotive will provide the key drivers, with a wide range of niche applications in several other industries accounting for the rest. The market researchers go on to cite that, "by temperature range, it was found that operation up to 200°C currently satisfies most requirements. However, as the technology matures, applications at higher temperatures will be enabled, around the year 2000, and are expected to account for 19% of the actual (total available) market by 2005. Silicon-based technologies are expected to dominate applications up to 200-250°C. GaAs and wide bandgap semiconductors (WBS) which include SiC, diamond, and Group III nitrides (III-N) will play critical roles beyond 250C, accounting for 16% of the high temperature electronics demand by 2005."

In attendance when these preliminary figures were presented by keynote speaker, Simon Lande, Director of Magus Research, Phil Neudeck's adds that "HiTEC in Albuquerque last June offered some interesting perspectives on technologies competing for the HTE market. The market survey paper presented at the opening session predicted that 5% of the HTE market would go to wide bandgap semiconductors in the year 2005, amounting to a somewhat small, by semiconductor industry standards, $50 million market. However, the paper included only those electronics whose atmospheric operational ambients exceed 125°C, thereby excluding the largest potential markets for wide bandgap semiconductors which lie in optoelectronics, power conditioning, and high-power microwave applications operating at room temperature atmospheric ambients with high internal junction temperatures. Furthermore, the survey was limited to totaling values for HTE semiconductor components without regard to the cost savings and performance enhancements those parts offer to larger systems. I think it's important to keep in mind that much of the value of high temperature electronics lies not in the parts themselves, but rather in the large system enhancements that these parts will enable." Simon Lande totally concurs. "Phil has provided a very perceptive analysis and his comments are absolutely right. However, the survey DID look at these aspects. In the presentation, the focus was on the component markets." The entire study is available through HITEN: http://www.hiten.com